



# Advanced Sensors for NASA's Exploration Missions



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## **Presented at**

**NSF Workshop/Short Course in Sensor Science and Technology**

**Alabama A&M University**

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- **The following persons from NASA/MSFC contributed to this presentation**

Raymond G. Clinton

Beth Cook

Jerry Fishman

Donald Frazier



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- **Outline of the presentation**

- The vision of the President of the United States of America for Space Exploration
- The report of the President's Commission on Implementation of United States Space Exploration Policy
  - Exploration Systems Interim Report
  - Major areas of sensor needs
  - Classes of material
  - Variety of Sensors for Space Exploration
  - Concluding remarks



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**On January 14, 2004, the President of the United States announced a new vision for the United States civil space program.**

***The goals of this vision are:***

- Implement a sustained and affordable human and robotic program to explore the solar system and beyond
- Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations
- Develop the innovative technologies, knowledge, and infrastructure both to explore and to support decisions about the destinations for human exploration
- Promote international and commercial participation in exploration to further U. S. scientific, security, and economic interests.





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**The President also created a Presidential Commission “to obtain recommendations concerning implementation of the new vision for space exploration.”**

***The Commission was chartered to make recommendations regarding:***

- A science research agenda to be conducted on the Moon and other destinations as well as human and robotic science activities that advance our capacity to achieve the policy;
- The exploration of technologies, demonstrations, and strategies, including the use of lunar and other in situ natural resources, that could be used for sustainable human and robotic exploration;
- Criteria that could be used to select future destinations for human exploration
- Long-term organization options for managing implementation of space exploration activities
- The most appropriate and effective roles for potential private-sector and international participants in implementing the policy
- Methods for optimizing space exploration activities to encourage the interest of America's youth in studying and pursuing careers in mathematics, science, and engineering
- Management of the implementation of the policy within available resources.



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- The Commission recognized that achieving the exploration objectives would require significant technical innovation, research, and development in focal areas defined as “enabling technologies”
- Exploration Systems Interim Strategy- Craig Steidle, NASA/Associate Administrator for Exploration System, August 2004
- *The Vision for Space Exploration: Objectives*
  - Implement a sustained and affordable human and robotic program to explore the Solar System and beyond
  - Extend human presence across the Solar System, starting with a human return to the Moon by year 2020, in preparation for the human exploration of Mars and other destinations
  - Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about destinations for future human explorations
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- Exploration Systems Interim Strategy- Craig Steidle, NASA/Associate Administrator for Exploration System, August 2004

## • Research and Technology Development

### *Focused Prioritized Requirements*

- Support NASA's requirements for near-term and future exploration missions
- To use the moon as a test bed for future human and robotic exploration
- Employ Research and Technology Development programs to address key gaps in performance or affordability with near-term capability development

### *Space Resource Utilization*

- Long-term goal to advance and mature technologies and systems that can extract, process, and refine materials for lunar and Martian resources



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- Exploration Systems Interim Strategy-Craig Steidle, NASA/Associate Administrator for Exploration System, August 2004 (continued)
- Research and Technology Development (continued)
  - *Advanced Space Technology Research*
  - Advanced Materials and Structural Concepts
  - *Focused Research and Development*
  - Human System Research and Development
  - Crew Health
  - Radiation
  - Advanced Life Support
  - Fission Power Systems



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- Exploration Systems Interim Strategy-Craig Steidle, NASA/Associate Administrator for Exploration System, August 2004 (continued)
- Research and Technology Development (continued)
  - *Novel Modes of Participation*
  - Innovative Technology Transfer Partnership
  - Research Partnership Centers

Research focus areas include in-space testing, power, propulsion, materials, in-situ resource utilization, imaging, communication, electronics, medical technologies, biotechnology, radiation mitigation, robotics, and sensors

- University Research, Engineering, and Technology Institutes



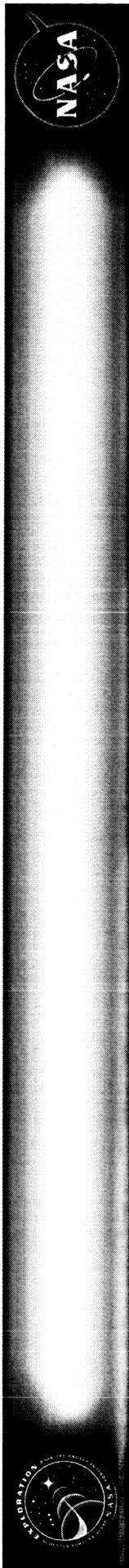


# Advanced Sensors for NASA's Exploration Missions

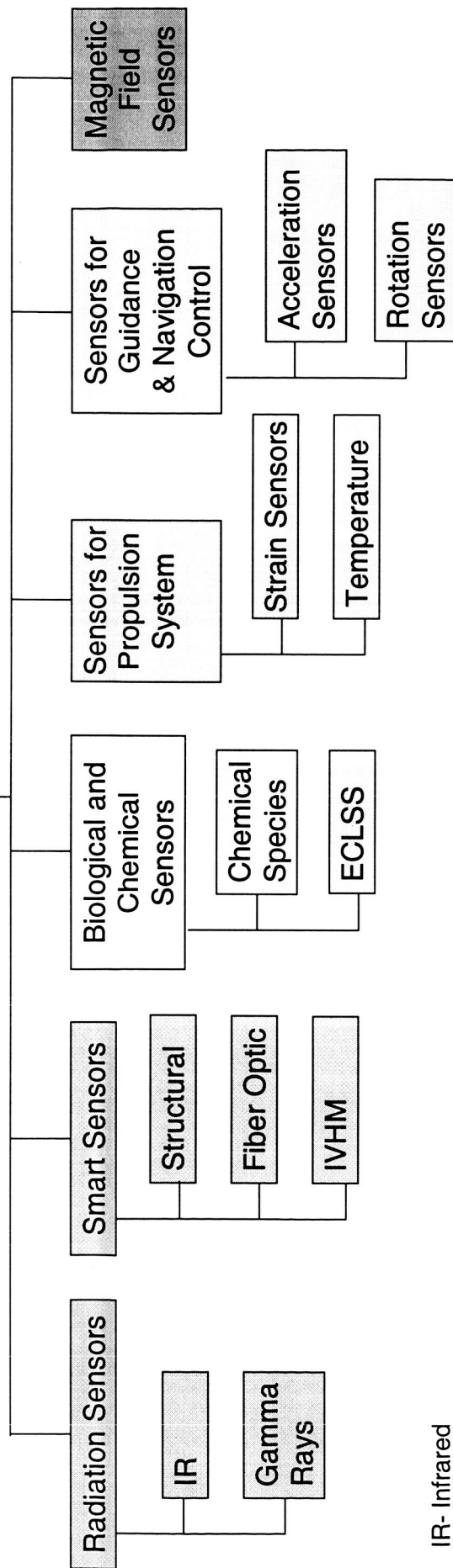


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## Different Sensors for NASA Exploration Missions



IR- Infrared

IVHM - Integrated Vehicle and Health Maintenance

ECLSS - Environmental Control and Life Support System



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## • *Variety of Sensors are required for Space Exploration Systems*

### ▪ Integrated Vehicle Health Management (IVHM)

Strain

Cracks

Temperature

Radiation

Fuel injector sensors (Hydrogen and oxygen resistant materials)

### ▪ **Environmental Control and Life Support Systems (ECLSS)**

Chemical sensors

Biosensors

Temperature sensors

Pressure sensors

Trace gas sensors

Dosimeters





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- *Variety of Sensors are required for the Space Exploration Systems (continued)*
  - Guidance Navigation and Control (GN&C)
    - Acceleration sensors
    - Rotation sensors
  - **Propulsion**
    - Fuel
    - Combustion
    - Combustion products
    - Fuel/oxidant ratio
    - Feed-back control
  - **Exploration**
    - Biosensors
    - Dosimeters
    - Compact, 'handy' spectrophotometers (IR, FIR, etc.)
  - **Radiation Sensors**



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### • *Variety of Sensors are required for the following Exploration Systems (continued)*

#### ▪ *New Detector Materials for High-Energy Astrophysics*

**Goal:** To provide space-borne detectors with large area and high efficiency

**Requirements:** Dense, high-Z, thick (~cm) detectors with large areas (~sq. meter)

Actively pursuing both scintillation and semiconductor (room-temp.) materials

- Scintillation detectors are read out with arrays of PMTs or silicon photodetectors
- Semiconductor detectors are read out by low-noise amplifiers
- Substantial on-board signal conditioning and data processing before transmission to the ground

NASA has had a long history of significant advances in high-energy astrophysics by many missions, using the latest detector technology

To continue these advances, new detector materials and the accompanying instrumentation are needed



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### ▪ *Variety of Sensors are required for the following Exploration Systems (continued)*

#### ▪ **Smart Radiation Sensors**

- Polymer composites with Embedded Fiber-optic Bragg Grating

#### ▪ **High Performance Nano-particle based Chemical Sensors**

- Wide band semi-conductive metal oxide materials
- Thick and thin film nano-composite materials

#### ▪ **Chemical Sensors**

- Smart Chemical sensors based on planar optical waveguide integrated with photo-elastic polymers
- Micro-electro-mechanical-systems technology using polymers
- Development of temperature and humidity sensors
- Rare-earth powders/doped glasses/fibers
- Other materials



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- *Variety of Sensors are required for the following Exploration Systems (continued)*
- **Sensor System for Effective Integrated Vehicle Health Monitoring**
  - Required for diagnostics, prognostics, and risk mitigation of all vehicle systems to support replacement of failed or near failure components
  - To greatly reduce ground maintenance costs
  - Assess structural strain, fatigue, and failure
  - To enhance the effectiveness and safety of the mission
  - Low weight/volume, spatial resolution
- **Types of Sensors**
  - All types of optical sensors
  - Fiber-optic Bragg Grating embedded sensor systems
  - Triboluminescent Material Sensors



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- *Variety of Sensors are required for the following Exploration Systems (continued)*
- ***Infrared Sensors***
  - Sensors for 3-5 and 8-14 and 15-60 micron wavelength ranges
  - Low cost un-cooled infrared sensors
  - High sensitivity broadband infrared sensors for satellite-based systems
  - Soil studies
- ***Magnetic Field Sensors***
  - New materials to improve the sensitivity of Giant Magnetoresistance (GMR) Tunneling Magneto-resistance (TMR) Sensors
  - Increase in resistance change with magnetic field using amorphous alloys
- ***Sensors for Propulsion System***
  - High temperature and strain sensors Integrated with material
  - Chemical and gas sensors
  - Impact Sensors



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- *Variety of Sensors are required for the following Exploration Systems (continued)*
- *Sensors for Ionizing Space Environment*
  - Radiation resistant polymer based photo-detectors (PPDs)
    - Incorporation of Quantum Dots into polymer matrix
    - Increase in radiation resistance
  - Development of InP and CdSe or other QD PPDs operating at near - IR wavelengths
  - Development of new and emerging QD materials for improving PPD performance